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ABSTRACT

The Solar Energy Task Force Report summarizes data, information, and discussions focusing on solar space and water heating applications. The report is intended to fill a need for curriculum and course development and direction for technical training programs, especially in vocational/technical schools and community colleges. It addresses curriculum suggestions; jobs, tasks, and skills for which training is needed; and equipment recommendations necessary in establishing a solar training center. In general, technical training which produces individuals strictly known as solar technicians, mechanics, installers, etc., is not advocated as the demand for purely solar jobs is uncertain. As such, solar specialization programs at the community college level should be added only in response to the needs of the community. Specific job tasks and functions are outlined for the following solar-related jobs: (1) sales; (2) estimator/designer; (3) installer; (4) electrician (not necessarily trained in the solar program); (5) supervisor; and (6) maintenance service. Examples of existing solar curricula and programs are offered, equipment needs are considered, and cost considerations in setting up a solar training laboratory are outlined. A reading list for solar energy is included. (MB)

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SOLAR ENERGY

TASK FORCE REPORT

ON

EDUCATION AND TRAINING

SEPTEMBER 12-13, 1978

DENVER, COLORADO

SPONSORED BY

THE SOLAR ENERGY RESEARCH INSTITUTE

GOLDEN, COLORADO

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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FORWARD

The Solar Energy Task Force Report summarizes data, information, and discussions stemming from the Task Force Workshop of September 12-13, 1978. The Task Force members, leaders involved with various aspect of solar technical training programs, were brought together to discuss the problems of training issues from the perspectives of education, labor, and business. This Task Force Report will be formally presented at the National Energy Education, Labor, and Business Conference on Energy-Related Vocational and Technician Training, Employment and Public Energy Awareness to be held in Washington, D.C., January 15-17, 1979, under Department of Energy, Office of Education, Business and Labor Affairs sponsorship. The Solar Energy Task Force concept was stimulated by the Department of Energy, and was coordinated and supported by the Solar Energy Research Institute.

The Task Force mission focused on solar space and water heating applications. The report is intended to fill a need for curriculum and course development and direction for technical training programs, especially in vocational/technical schools and community/junior colleges. The report addresses itself primarily to the questions of curriculum suggestions; jobs, tasks and skills for which training is needed; and equipment recommendations necessary in establishing a solar training center. As well, the fundamental issues centering on the questions of whether or not to offer a solar program are addressed.

On behalf of the members of the Solar Energy Task Force, this report is presented. It is hoped that this will be a useful document for all those involved in, or anticipating involvement in, solar technical training.

J. Kevin O'Connor
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Technical Training Guidelines

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NOTICE

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SOLAR ENERGY TASK FORCE REPORT

CHAPTER I: Introduction

Meeting of Task Force

The Solar Energy Task Force met September 12-13, 1978, for the purpose of developing suggested guidelines for solar energy technical training programs. A group of 12 leaders in the solar technical training area represented segments of education, labor and business. See Page iii for a list of the Task Force members.

Report Scope and Purpose

This Task Force Report is geared to providing a set of program suggestions, especially oriented toward programs of current commercial technology in solar energy, specifically water and space heating. While space cooling and other solar applications are technically feasible and applicable in certain areas, they are in general not economically viable today. The suggestions are especially prepared for those in the solar technical training community and are geared to suggesting sample curricula and programs; technical jobs, tasks and skills; and equipment recommendations designed to assist those institutions considering the development of solar educational offerings in the technical training area. While the report discussion generally centers on active systems for space heating and hot water applications, a well-rounded program needs to focus early on energy conservation retrofitting and incorporating passive design techniques in new and existing buildings.

Use of Report

This report is not to be viewed as inviolate in its suggestions, but is intended to be a guide to those wishing general information to assist in the decision-making process. Some topics not considered in depth in this report will also be important in deciding whether or not to enter the educational arena. It is suggested that one using this document carefully review the points which appear in the second chapter, "Task Force Summary."

General Note of Caution Regarding Solar Program Development

The need for a sharp increase in the development of solar program offerings has not been established. Historically, once academic institutions have responded to market demands, it has been difficult to stem the tide. The dangers are as inherent in solar as in physics or space engineering. The addition of solar courses, programs, or curricula should not be made solely in response to popular demand, but also in response to an assessment of market needs. As well, the education institutional antennae should be sensitive to the training taking place in the private and industrial arenas.

Other Alternate Sources of Energy

This Task Force Report deals with solar heating applications primarily because this technology represents commercial, and, in some cases, economically feasible applications today. Any new technical training programs to be offered should be responsive to current market needs, i.e., jobs must be available! Hence, concentration on other solar applications and other alternate sources of energy was not considered. The areas of solar and other alternate sources of energy in which considerable research and development work is ongoing, and which are in various stages of applicational readiness, include: solar cooling, biomass generation and conversion, wind energy, ocean thermal energy conversion, solar agricultural and industrial process heat, solar thermal energy conversion to electricity (power tower or central receiver concept), photovoltaics (direct electrical conversion using solar cells), and solar power satellites.

CHAPTER II: Task Force Summary

Objectives

The Solar Energy Task Force met for the specific purpose of accomplishing three objectives which might be responsive to meeting an information void in the field of education, labor and business for technical training programs. The three primary objectives addressed by the Task Force were:

1. Solar Jobs, Associated Tasks and Skills. The following jobs/job functions were identified as those necessary for training programs to consider when arranging solar programs or curricula: a) Sales; b) Estimator (or Designer); c) Installer; d) Electrician (not necessarily trained in the solar program, but needed in some solar installations); e) Supervisor; f) Service (Maintenance) Technician. Chapter III presents associated details of tasks and skills required for each solar related job. Each job identified should not necessarily be construed to mean that a different individual perform each job. The jobs might better be viewed as functions required in a solar installation with the size and complexity of the installation being the determining factor.
2. Sample Curricula and Programs. Questions often raised by institutions looking to enter into solar education are: "Where do I start?"; "What programs currently exist?"; "How do I get more information?". Chapter IV and Appendix I attempt to respond to this need. It is noted that a host of curricula, programs and courses are currently being offered across the U. S. One should be cautioned that those presented in this report are not necessarily the best. They are meant to be samples only and, as such, should serve as reasonable starting points for program planning and development.

There is not sufficient experience in the solar business to pass judgment on which programs now being conducted are the best. Different programs are designed to meet different needs. For example, an educational program geared to retraining already skilled individuals need not be as comprehensive as one oriented to the high school graduate looking for training at the job entry level. A critical consideration must be the target audience for which the program is being offered.

3. Programs for Instructors. In addition to student-oriented curricula, a need for programs oriented toward instruction of teachers has been recognized. The program offered at Colorado State University and the newly developed training programs in the League for the Innovation of Community Colleges are two examples described in Chapter IV.

4. Equipment Needs. All training programs require special equipment for the classroom and laboratory. In the emerging field of solar technology, a multitude of teaching programs and tested equipment for optimum classroom/laboratory experience does not exist. The attempt in Chapter V and Tables 6-9 is to offer equipment suggestions which have been developed and/or proven useful in the experience of others. While a suggested cost for the purchase of solar equipment and teaching aids might be in the order of $20,000, costs of $50,000 are probably not unreasonable for a well-equipped hands-on situation.

Cautions/Recommendations/Report Summary

In addition to the major objectives cited above, many important issues were discussed, some of which impinge directly on the decision-making process of developing and offering solar curricula or courses.

1. In general, this Task Force does not advance a position of advocacy in technical training which produces individuals strictly known as solar technicians,

mechanics, installers, etc. It is emphaized that because the demand for purely solar jobs is uncertain, training a person for job entry as a strictly "solar" anything might not assure employment.

It should be noted, however, that the future direction of solar energy may be altered dramatically with the passage of the National Energy Act, additional solar incentive legislation, state and local incentives and other promotional activities, both voluntary and involuntary. Were the Task Force to meet again within the coming year, it might do an about-face relative to advocating the need for strictly solar training.

At the Community College of Denver, Red Rocks Campus in Golden, Colorado, where a two-year solar technician's training program is into its second year of operation, Craig Hilton, Solar Energy Instructor, indicates nearly all of his students are finding solar employment. One should not generalize from the example, however. Follow-up studies on continued employment in the solar field are necessary. It is also noted that many small solar businesses and manufacturers are having difficulty surviving. In fact, many are not. Whether the National Energy Act will reverse this trend for small businesses remains to be seen.

2. When considering the creation of a solar program, an educational institution should understand the contents to be included in the curriculum and coursework, the required tasks and competency levels for the trained personnel, and a feeling for recommended equipment in putting together the solar laboratory. Chapters III - V address those needs in detail.
3. The technical training school is encouraged to make use of an Advisory Council composed of members of local industry, present solar installers and contractors, labor organizations, and building contractors, to name a few. Such

Advisory Council should be utilized in the initial process of fundamental need assessment for the program under consideration. The Advisory Council can serve several functions: 1) make recommendations on solar programs relative to technical training issues and needs; 2) maintain awareness within the school of the current manpower requirements in the solar market to help alleviate mistraining and/or overtraining; 3) provide speakers for certain programs; and 4) create links with local business and industry to facilitate job placement.

4. Solar program offerings can be quite diverse in both content and length. Each institution must consider the variety of solar jobs for which it could possibly train students in the solar field and whether each program: (a) will respond to the need for training at the job entry level; (b) will be geared to retraining; or (c) will be simply awareness oriented. In considering the student target audience, it has been noted that a large portion of students taking solar education programs are already gainfully employed and older than the average student.

5. A person receiving solar training should be well-rounded in HVAC* and plumbing fundamentals. Schools and institutions already offering HVAC programs can expand most easily to include solar offerings. In fairness to students going through programs at the job entry level, they should be well trained in HVAC and plumbing skills with the appropriate addition of solar emphasis into the HVAC training program.

6. In general, the Task Force held that solar specialization programs at the community/junior college level should be added only in response to the needs of the community. The fact that solar programs might be fashionable should not be taken as a sufficient condition to offer a solar program of some type.

*HVAC = Heating, Ventilating, and Air Conditioning

7. The Task Force generally advocated that there was no need for the development of a "solar" engineer. Engineers wishing to emphasize solar would be trained in a traditional discipline with specialization in solar which would not preclude his entrance into other lines of work.

CHAPTER III: Solar Jobs, Associated Tasks and Skills

It is important that an educational institution understand the variety of jobs and job functions for which students intended to be practitioners in the solar field need to be trained. Not every institution or every program will train each student to be proficient in each of the jobs necessary for a successful solar installation. Some institutions may choose the route of only offering one or two courses aimed at community awareness, whereas others might choose to offer a full two-year curriculum aimed at training the "solar" mechanic or technician. Types of training programs offered and program/course/curricula content will be dependent on the target level of the audience and the program purpose.

The Task Force identified six jobs (job functions) which could be incorporated into solar installations. The jobs consist of the following: 1) sales; 2) estimator/designer; 3) installer; 4) electrician (not necessarily trained in the solar program); 5) supervisor; and 6) service (maintenance). Depending on the orientation and length of the program or curriculum, persons will be proficient in one or more of the above jobs or job functions. On large installations, usually of the commercial or industrial types, the above list will, in fact, represent unique jobs. On smaller installations, for example, domestic hot water on a residential home, one or two individuals may perform the total range of job functions.

The detailed tasks and skills associated with each job/job function were identified by the Task Force. The list of tasks and skills will be useful in creating programs and curriculum details tailored toward specific jobs. The jobs and associated tasks/skills are:

A. Sales. The solar salesman with insufficient knowledge of solar systems and applications will be detrimental to the commercialization of the solar industry. Solar sales personnel must be well-versed in the various applications of solar and be able to:

1. Describe Different Systems. The sales person should be conversant with all types of solar heating and cooling systems, including domestic hot water applications. The sales person must also understand conventional HVAC systems and how solar systems will tie in with various conventional types in the case of solar retrofits; or be able to match solar systems with HVAC systems in new applications.
2. Show the Finished Product. The sales person must be able to explain and show the details of the finished system, including how it will look on the building, where the various components will be placed, and any other structural impacts on the building which the system may have.
3. Explain Performance. The sales person must be able to describe the expected performance of the solar system; how it will operate with the conventional system; and describe the energy, under average conditions, which the system should be able to deliver to the building. The sales person must have the ability to demonstrate energy saving expectations of the particular system under consideration.
4. Recommend a Particular System. The sales person must be sufficiently familiar with solar componentry to be able to recommend an optimum system for each application. Knowledge of which components work best together and know how to design and size components properly to insure successful system operation will also be necessary.
5. Explain System Operation and Maintenance. The sales person must be intimately familiar with the various modes of operation so that each mode can be explained clearly. An ability must be demonstrated to

detail each mode of operation and show how the controls will activate the various modes, including which pumps, motors, blowers will be active in each mode, and the open/close positions of various valves and dampers with each system contingency. The sales person must know and communicate the maintenance operations and intervals which will be necessary for each particular system installation.

6. Explain Impact on Comfort. The sales person must be able to explain any possible affects on comfort level which the solar system might have. Potential impacts on humidity, time/temperature fluctuations, and noise levels must be noted where necessary.

7. Estimate System Costs. A primary interest to the customer will be the additional cost of solar system for a retrofit situation or the cost above the conventional system for a new installation. The sales person must know how to estimate costs of components, labor, energy usage, etc. An estimate of system savings on the energy bill must be made, although it was suggested that emphasis should not be placed on investment payback periods. The sales person must have knowledge of local, state and federal solar incentive programs for tax credits, rebates, etc. As well, a knowledge of local building codes and insurance practices relative to solar construction will be necessary.

B. System Designer. The system designer is responsible for laying out the details of the solar system. As such, the designer will be the main interface person between the project architect and mechanical engineer. The system designer will be responsible for providing the intricate details which will insure successful system installation and interconnection with the conventional HVAC system. Therefore, a need exists to

have detailed operational knowledge of conventional and solar systems. The system designer must be able to:

1. Select the Proper System Type. From among the myriad of solar systems available, the system designer must be able to select the proper type of system which will be appropriate for: a) meeting building's heating/cooling load requirements; b) geographic location; c) integration into the architectural design; d) complying with the maximum structural stress of the area in which the system is integrated; and e) all local code requirements.
2. Select Optimum System Size. While larger systems properly sized with storage will yield more energy to the consumer, a crossover point exists on the cost/benefit scale beyond which it is not prudent to invest in a larger system. (In addition, available collector surface area may be exceeded). The system designer must be able to select the optimum system size based on knowledge of expected performance and system economics. A familiarity with the method of calculating optimum system size and with the tools available to do the job (usually computer/calculator programs; for example, FCHART, SOLCOST, etc.). must be part of the designers repertoire.
3. Calculate System Performance. The system designer should be able to calculate system performance for any system type in any geographic location. A knowledge must exist of how to calculate building heat loads for sizing the system (task 2) and how to merge this information into the predicted energy savings (contribution) which the solar system will provide. Tools such as FCHART and SOLCOST for helping to select optimum system size with solar would be useful in calculating system performance.

4. *Identify Impact on Building Design.* *With Task 1 above, the system designer will select the appropriate solar system which will best fit with the architectural design and allowable structural loads of the building.*

5. *Provide Information on Operational Details.* *The system designer must be able to create the necessary detailed drawings, charts, tables, etc., which size and locate solar system components in the buildings. Drawings and charts will also indicate the various modes of operational detail sufficient for the architect and mechanical engineer to understand and use. The detailed drawings should also be sufficient for the installer, electrician, supervisor and maintenance (service) persons to perform these tasks. The operational detail will include, but not be limited to, the following:*

   a. *Detailed drawings and descriptions of each mode of operation, including location and position of ducts, dampers, valves, etc. for the particular mode addressed;*

   b. *Operational ranges of system controls for each of the modes;*

   c. *Collector placement, altitude and azimuth angles, attachment to building structure;*

   d. *Detailed drawings and description of piping and duct connections, sizing, flow balancing considerations, etc.;*

   e. *Component sizing and location of collectors, pumps, blowers, storage;*

   f. *Detailed drawing and description of the storage component and interconnections.*

6. *Describe Installation and Maintenance Details.* *The information itemized in Task 5 should provide the necessary details for the*

system installer. In addition, the system designer should describe the routine, expected maintenance operations and scheduling of such operations.

C. Installers. System installers will need to have intricate knowledge of installation and construction of solar component hardware, as well as a fundamental knowledge of HVAC systems. In addition, they should have a general knowledge of system operation and design and local building codes. The installer is the "hands-on" person capable of translating the designer's blueprints into a properly installed system. The installer should demonstrate the skills of good craftsmanship in all the work performed. As such, the installer should be able to:

1. Install Collectors. Be familiar with the variety of installation techniques, mounting hardware and collector interconnections. The installer must be able to mount, fasten, and flash collectors as necessary to insure that collectors and support structures will withstand local climatic conditions (wind, hail, snow, etc.) and prevent roof leakage and rotting.

2. Make System Connections to Collectors. The installer must be totally familiar with the kinds of connections which should be made in each solar system type, including both air and liquid systems. The installer must be familiar with the various types of fittings and unions and the soldering and sheet metal techniques associated with making such connections. In fitting collectors together and in attaching system connections, allowances for thermal expansion must be understood and incorporated.

3. Leak Test System. Collectors should be leak tested prior to installation for both internal leakage faults in the absorber plate and external leakage through the collector housing. The installer must also be able to flush the system (in the case of liquid systems), fill the system with the appropriate fluid, and pressure test the system for leaks.

4. *Locate, Construct and Install Storage. The installer should be familiar with various types of storage systems, containers, tanks, etc., which can be employed in solar systems.* The installer should be able to construct *storage systems, usually in the case of rock storage/air systems. Familiarity with considerations for properly locating the tank or storage bin must be understood, i.e., allow room for interconnections, insulation, servicing, etc.*

5. *Connect Pipes, Ducts to Storage. The installer must be able to read the designer blueprints to be able to properly connect pipes and air ducts, when applicable, to the storage container. Along with Task 2 above this includes proper pitching of pipes and use of appropriate (right type and R-Value) insulation of pipes and ductwork. This task* could *also involve the installation of storage sensors which will be connected to the system controller.*

6. *Install Collector/Storage Heat Exchangers, Pumps, Check Valves, Filters, Isolation Valves and other necessary hardware which interconnects and affects the collector/storage operation.*

7. Hookup *System with Auxiliary (Standard Backup) Heating Unit, including the use of filters, humidifiers, etc.*

D. *Electrician. Basically, the electrician will be used for the installation of* solar controls. The electrician may not be familiar with the detailed operation *of solar systems, but should be able to interpret the system information (drawing, blueprints, etc.) for successful hookup of the solar control system. On smaller systems, usually retrofits, where there is no need to connect wiring to the main service box or work directly with the 110 vac lines, then an electrician may not be necessary. In larger systems, especially larger commercial and industrial applications, an electrician will be needed.* The electrician must be able to:

1. *Provide Power* to main control unit, blowers, pumps and any safety controls which the system may employ.
2. *Install Sensors*, if necessary, or insure that they are installed properly.
3. *Install Thermostat*.
4. *Connect Mechanical Device Controls to Controller*.
5. *Check Out Control Modes*. This should be done in cooperation with the person responsible for system startup.

E. *Supervise (Construction and Installation)*. The supervisor of the construction and installation of the solar system will need to:

1. *Establish Schedule*. The supervisor will need to coordinate the delivery of materials with manpower schedules to insure that the installation goes smoothly and on time.
2. *Recognize Conformance with Codes*. The supervisor must insure that the solar installation does not violate any of the local building codes, ordinances, etc.
3. *Recognize Conformity of Installation with Design*. The supervisor must constantly check, as installation progresses, that the system is being installed without variance, unless approved, to the original system design.

F. *Service (Maintenance)*. The service or maintenance technician needs to be extremely well-versed in all facets of solar system operations. As such, the service person must be able to:

1. *Understand the General System Operation*. Before tackling any service or maintenance operation on any system, the service person must have a working knowledge of such system.

2. *Identify the Control Modes of the System.* The service person must have a working knowledge of controller circuitry and associated wiring, understand the proper location and installation of sensors, and the temperature ranges and control points affecting the operation of various system modes.
3. *Determine if Mechanical Devices are Operational.* Must have experience in motor repair and operation as well as the operation of various valve types (gate, balancing, pressure-temperature relief, air vents, solenoid, etc.)
4. *Identify Proper Points for Fluid Temperature Measurements.* Must be able to analyze whether sensors are installed properly and in proper locations for system to operate as designed.
5. *Determine if Heat Flows are "Nominal".* Must have sufficient knowledge of heat transfer principles to make calculations based on observed temperature measurements to determine if the actual heat flows are within the acceptable tolerances as compared to theoretical.
6. *Identify Location of Problems.* Must be able to coordinate systems knowledge, systems operation, and testing and measuring techniques to be able to localize the problem(s).
7. *Fix Problems.* Once the problem has been isolated the service/maintenance person must have the ability to fix the specific problem. In some instances, the service person may have isolated the problem, but will not be able to perform the repair himself. In such cases, the service person must know whom to contact to correct the situation.
8. *Perform Periodic Maintenance Checks.* Maintenance of pumps, motors, blowers and anti-freeze checks may be required, depending on the system type. Changes of filters and system flushing may be needed in certain systems. The maintenance person should be able to perform

all the maintenance tasks as specified by the system designer.

9. Perform System Startup. On small system installations, for example swimming pool and domestic hot water applications, the system startup function will be performed by the service/maintenance person. Knowledge to perform the tasks listed above should be sufficient to be able to check out and correct problems in smaller systems. In larger, more complex systems, especially in commercial and industrial applications, the systems startup function will be performed by one well-versed in large-scale applications who will have full working knowledge of the total system operation (design function), installation, electrical, service/maintenance. Insurance that the system is operating as designed is the task of the system startup person. In the larger systems, the system startup person may be supervising a team of persons as the system is engaged. System startup in larger systems may be the responsibility of the mechanical contractor.

Chapter III has focused on six jobs/job functions. An alternate approach to classification of job functions and tasks was done in a master's thesis done by William D. Hunt of California State University at Chico, California, entitled "Solar Technicians and Mechanics: A Preliminary Occupational Task Analysis." Provided in this thesis are detailed task requirements for two jobs identified in the emerging solar heating and cooling industry. See Tables 1 and 2 for a listing of predominant solar technician and mechanic tasks as identified in this thesis.

CHAPTER IV: Sample Curricula and Programs

Introduction

Many different courses, programs and curricula exist in the field of solar energy. None have long track records, but those which do exist have been popular. A sample of some of these programs, as well as some new or proposed programs, will serve as examples which others may follow, embellish or change, but, at the least, will learn from these experiences and need not break virgin ground.

It should be noted emphatically that new solar related courses, programs and curricula should not be started by persons without solar experience or background. New solar-related offerings should only occur as a result of contracting for outside course development by experienced personnel in the field or by drawing upon the creative experience and wisdom of those already in the field. Numerous references and sources of references are available. (See Appendix II).

Specific information relative to courses, programs, and curricula offerings throughout the United States will be published by the Solar Energy Research Institute (SERI), Golden, Colorado. Information was collected from a national survey* of educational institutions in August and September 1978 under the sponsorship of Congressman George E. Brown, Jr. of California and the Congressional Solar Coalition. Information processing is being handled by the Solar Energy Research Institute with the results of the survey becoming part of the Congressionally mandated Solar Energy Information Data Bank. A Solar Energy Education Directory will be available from SERI, Congressman Brown's Office, and the National Solar Heating and Cooling Information Center in early 1979.

*Credits for the survey implementation go to John Kimball, Staff Assistant to Congressman Brown and Kevin O'Connor, Solar Energy Research Institute.

The Directory will list all educational institutions (by state) offering at least one solar-related course, with some descriptive material relevant to each offering. Appendix III contains an initial list of educational institutions offering a solar program or curriculum in the technical training area. Most of the information reported here was obtained from the educational survey just described. The list is not all inclusive, but is representative of available information.

The following samples of solar curricula and programs are offered to give a feel for the state-of-the-art in solar curriculum offerings. As yet, there is no clear method devised for passing judgment on the solar curricula or programs. They should be used as planning tools, as starting points of reference, in new program development.

Clark County Community College

Contact: Mr. David Comarow, 3200 E. Cheyenne Avenue, North Las Vegas, Nevada 89030.

Clark County Community College has recently initiated a solar technician training program. Initial solar course offerings began in January 1977, with degrees expected to be approved for the fall of 1979.

The Program consists of a 30-credit curriculum leading to a "Certificate of Achievement in Solar Energy Technology." The program will be tied very closely with the Air Conditioning/Refrigeration Program, also offering a 30-credit "Certificate of Achievement." A student completing both Certificate of Achievement programs will receive a 60-credit "Associate of Applied Science Degree in Air Conditioning-Solar Technology." The proposed curriculum for the "Certificate of Achievement in Solar Energy Technology" program is as follows:

SOL 119B	Introduction to Solar Energy Technology	4
SOL 201	Advanced Solar Energy Technology	4
SOL 130	Passive Heating and Cooling Techniques	3
SOL 210	Practicum in Solar Technology	3
Dft 123B	Blueprint Reading	(3)
or		or
*	Industrial Electronics	(3)
ENV 117	Energy and Society	(3)
or		or
ENV 109	Ecology and Environmental Science	(4)
Communications Courses		6
Electives		6
		33 - 34

Further solar courses will be developed and offered as needed.

Colorado State University

Contact: Dr. Susumu Karaki, Solar Energy Applications Laboratory, CSU, Fort Collins, Colorado 80523.

The Colorado State University's Solar Energy Applications Laboratory has developed two of the most comprehensive manuals for training the solar practitioner. The titles of the manuals are: "Solar Heating and Cooling of Residential Buildings: Sizing, Installation and Operational Guidelines" [1], and "Solar Heating and Cooling of Residential Buildings: Design of Systems" [2]. The course is modularly oriented and has been offered in one week schedules, but some schools* are using the manuals, with supplemental information, as the basis for training programs. Each manual is over 700 pages in length.

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*For example, the Energy Conservation and Solar Applications Training Center (Charles Paul, Director) 1417 Newport Road, Wilmington, Delaware 19804 is using the CSU Manuals in its solar applications training courses.

The modules into which the training manuals are separated are indicated in Figures 1 and 2, which show the course schedules and modules of week-long programs.

Community College of Denver - Red Rocks Campus

Contact: Craig A. Hilton, 12600 W. 6th Avenue, Golden, Colorado 80401.

The CCD - Red Rocks Campus, a two-year institution, has a most active solar technical training program. The program is in its second year of operation. Certificate and associate degrees are available in "Solar Energy - Installation and Maintenance." A short description of the programs and courses is given in Table 3. Course materials utilized in the Community College of Denver - Red Rocks Campus Program are found in Appendix I.

Navarro College

Contact: Charles Orsak, P.O. Box 1170, Corsicana, Texas 75110.

Navarro College has developed an associate degree curriculum under a grant from the National Science Foundation (NSF), and in cooperation with Bevard Community College, Cocoa, Florida; Cerro Cosa Community College, Ridgecrest, California; and Dallas County Community College District. The final package of the program is to contain instructor's guides, student workbooks, equipment lists, and curriculum. Table 4 gives the proposed curriculum outline for Navarro College's Solar Engineering Technician.

Scott Community College

Contact: Robert N. Illingsworth, Belmont Road, Bettendorf, Iowa 52722.

Scott Community College has developed a curriculum for Solar Energetics Technology. The curriculum runs for eight quarters and is predominantly an HVAC program with several solar courses. The program, which began in February of 1978, consists of 149 credits and 2,880 clock hours.

For a list of courses, clock and credit hours, see Table 5.

Department of Energy - Community College Instructor Training - Contact: Debra Langford (202) 376-1983, Conservation and Solar Applications, DOE, Room 2221C, 20 Massachusetts Avenue, N. W., Washington, D. C. 20545.

Under contract with DOE's Solar Market Development & Training Program, the League for Innovation in the Community College, a national consortium representing 50 Colleges, is developing curriculum materials and procedures for training community college instructors to teach the skills necessary to install solar systems. Specifically, the Project will:

1. *Train a minimum of 60 community college vocational technical faculty members from 9 districts (38 colleges) in the Western United States to teach the techniques and skills relating to the installation of solar systems.*
2. *Train two member teams from the 9 districts to develop and implement programs for training solar system installers.*
3. *Based on results of the Western Region Program, duplicate program for Eastern/Midwestern community college districts.*
4. *Explore the use of television as an instructional mode for training solar system installers.*
5. *Develop a format for the training of installers.*
6. *Establish a network for the community college districts in order to share information relating to solar systems*

CHAPTER V: Equipment Needs for Solar Training

Any references to specific manufacturers or products is not meant to be an endorsement of any *product or service, but is listed for information purposes only.*

The cost and process of setting up a laboratory for solar training has varied greatly from institution to institution. In general, the Task Force agreed that for around $20,000, an effective solar laboratory could be initiated. If funding is not available in lump sum at the beginning of a program, it is suggested that the equipment be purchased in stages. The costs (or suggested costs of equipment) for the schools listed here is summarized:

School	Solar Equipment Costs
Clark County Community College	$57,275
Community College of Denver - Red Rocks Campus	$21,000
Navarro College	$45-55,000
Scott Community College	$54,000

Because solar educational offerings are in the embryonic stage, so is the development of standard laboratory equipment for solar energy. Following is a list of major equipment items which are in use or planned for use in technical training programs in several community colleges. The emphasis is on hands-on equipment, models, and diagnostic training aids.

Clark County Community College

Highly innovative custom designed equipment is utilized in the Clark County Community College Solar Program. All equipment is specially designed to carry out a logistically integrated educational program. Much of it centers around a central control -- monitoring package (CCMP). This unit contains the capability to control most active solar systems, from the simplest to the most complex; as well as to collect and record data from a variety of energy systems.

A unique piece of equipment, designed and built especially for Clark County Community College, is the Modular Liquid System Trainer (MLST), having totally interchangeable components, consisting of a generous supply of tanks, pumps, valves, heat exchangers, pipe, and other typically utilized components. Any system assembled can be monitored and controlled with the Central Control Monitoring Package.

Collector Arrays are also utilized, consisting of a number of types of liquid collectors, including a simple unglazed swimming pool type, a single-glazed nonselective flat plate, a double-glazed selective flat plate, an evacuated tube module, and a concentrating parabolic tracker.

Air Systems may be simulated using a unique 1/8 scale Model Air System.

Passive Solar Systems are studied utilizing model passive homes, a simulated sun and temperature monitoring through the Central Control-Monitoring Package.

In order to get hands-on experience installing and maintaining Solar Swimming Pool Collectors, a simulated roof-mounted solar swimming pool collector unit (at ground level) is provided to assemble, repair, and disassemble. The specific equipment and associated prices utilized in the Clark County Community College Program are found in Table 6.

Community College of Denver - Red Rocks Campus

The list of equipment utilized by the Community College of Denver, Red Rocks Campus, is found in Table 7.

Navarro College

Navarro College is currently offering the one-year solar mechanics program and expects to offer the solar technician program in the Fall of 1979. A list of major equipment items proposed by Navarro College is found in Table 8.

Scott Community College

The equipment list utilized by Scott Community College in their technical training program is presented in Table 9.

	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
0900		MODULE 1 (30 min) Course Orientation MODULE 2 (90 min) General Descriptions of Solar Heating and Cooling Systems	REVIEW AND QUESTIONS (30 min) MODULE 7 (90 min) Detailed Design Methods	REVIEW AND QUESTIONS (30 min) MODULE 11 (90 min) Collectors	REVIEW AND QUESTIONS (30 min) MODULE 15 (90 min) System Controls	REVIEW AND QUESTIONS (30 min) MODULE 20 (90 min) Design Case Study
1000		COFFEE (30 min)	COFFEE (30 min)	COFFEE (30 min)	COFFEE (30 min)	COFFEE (30 min)
		MODULE 3 (90 min) Solar Radiation Information for Design Purposes	MODULE 7 cont (30 min) Detailed Design Methods MODULE 8 (60 min) Economic Considerations	MODULE 11 cont (30 min) Collectors MODULE 12 (60 min) Storage Systems	MODULE 16 (90 min) Selection of Subsystem Components	MODULE 21 (45 min) Structural, Mechanical and Scheduling Considerations MODULE 22 (45 min) Future Prospects for Solar Heating and Cooling Systems
1200		LUNCH (60 min)	LUNCH (60 min)	LUNCH (60 min)	LUNCH (60 min)	LUNCH (60 min)
1300	1400 - Registration 1445 - Solar House Tours	MODULE 4 (60 min) System Design Guidelines MODULE 5 (60 Min) Heating and Cooling Load Analyses	MODULE 9 (120 min) Energy Conservation Trade-offs	MODULE 13 (120 min) Laboratory	MODULE 17 (120 min) Solar Cooling Systems	MODULE 23 (60 min) Buyer's Guide Review and Summary (60 min)
1500		COFFEE (30 min)	COFFEE (30 min)	COFFEE (30 min)	COFFEE (30 min)	COFFEE (30 min)
		MODULE 6 (90 min) Simplified Design Calculations	MODULE 10 (90 min) Detailed Design Calculations	MODULE 14 (90 min) Computer-Aided F-Chart Calculations	MODULE 18 (45 min) Automated Design Techniques MODULE 19 (45 min) Service Hot Water Systems	Evaluation of the Course by participants
1700		ADJOURN	ADJOURN	ADJOURN	ADJOURN	ADJOURN
1730	Reception and Dinner					Dinner and Awards

Figure 1 Course Schedule*

*From "Solar Heating and Cooling of Residential Buildings: Design of Systems", Solar Energy Applications Laboratory, Fort Collins, Colorado, P. 1 - 3

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	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
0800		MODULE 2 (45 min) Course Orientation MODULE 3 (75 min) Introduction to Solar HAC Systems	OPEN DISCUSSION (30 min) MODULE 6 (90 min) Thermal Storage Subsystems	OPEN DISCUSSION (60 min) MODULE 10 (60 min) Solar Heating and Cooling Systems	OPEN DISCUSSION (30 min) MODULE 13 (90 min) Heating Load Calculations	OPEN DISCUSSION (30 min) MODULE 17 (90 min) Cost Effectiveness of Energy Conservation
1000		COFFEE (30 min)	COFFEE (30 min)	COFFEE (30 min)	COFFEE (30 min)	COFFEE (30 min)
		MODULE 4 (90 min) Solar Radiation	MODULE 7 (90 min) Service Hot Water Systems	MODULE 11 (45 min) Control Subsystems MODULE 12 (45 min) Operations Laboratory	MODULE 14 (60 min) Solar System Sizing MODULE 15 (30 min) System Economics	MODULE 18 (45 min) Retrofit Considerations MODULE 19 (45 min) Scheduling of Solar Installations
1200		LUNCH (60 min)	LUNCH (60 min)	LUNCH (60 min)	LUNCH (60 min)	LUNCH (60 min)
1300		MODULE 4 cont (60 min) Solar Radiation	MODULE 8 (120 min) Solar Heating Systems	MODULE 12 cont (240 min) Operations Laboratory	MODULE 15 cont (30 min) System Economics	MODULE 20 (60 min) Constraints and Incentives
1400	REGISTRATION Solar House Tours	MODULE 5 (60 min) Fluid-Heating Solar Collectors			MODULE 16 (90 min) Solar System Sizing Calculations	MODULE 21 (60 min) Buyer's Guide
1500		COFFEE (30 min)	COFFEE (30 min)		COFFEE (30 min)	COFFEE (30 min)
		MODULE 5 cont (90 min) Fluid-Heating Solar Collectors	MODULE 8 cont (30 min) Solar Heating Systems MODULE 9 (60 min) Solar Space Cooling Systems		MODULE 16 cont (90 min) Solar System Sizing Calculations	Final Discussion and Critique (90 min)
1700		ADJOURN	ADJOURN	ADJOURN	ADJOURN	ADJOURN
1730	RECEPTION AND DINNER MODULE 1 (30 min) Energy Problem					AWARDS DINNER MODULE 22 Future Prospects for Solar HAC Systems

Figure 2 Course Schedule*

*From "Solar Heating and Cooling of Residential Buildings: Sizing, Installation and Operation of Systems", Solar Energy Applications Laboratory, Fort Collins, Colorado, P. 2 - 3

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TABLE 1

PREDOMINANT SOLAR TECHNICIAN TASKS*

Solar Technician Task Requirement
-- Read blueprints and/or schematics.
-- Calculate heat loss/gain in buildings.
-- Size solar collector array.
-- Prescribe appropriate automatic solar controls.
-- Size water storage sub-systems.
-- Draft blueprints and/or schematics.
-- Perform supervisory functions.
-- Trouble-shoot, maintain and repair solar controls.
-- Size or prescribe solar plumbing, to include pumps, based on "rule of thumb" procedures.
-- Size solar-assisted heat-pump systems.
-- Size auxiliary back-up heating systems.
-- Size or prescribe solar plumbing, to include pumps, based on flow rates, friction loss, and other data.
-- Size heat exchanger units.
-- Size rock storage sub-systems.
-- Sell solar apparatus.
-- Size or prescribe solar-pond or solar-wall (thermal mass) systems.
-- Size south-facing window systems.
-- Prescribe types of movable insulation and apparatus in passive systems.
-- Perform administrative functions.
-- Calculate heat loss/gain in storage systems.
-- Install and wire solar control systems.
-- Maintain and repair solar collector array.
-- Design duct work requirements.
-- Size or prescribe heating ducts, vents, and blowers based on "rule of thumb" procedures.
-- Size or prescribe heating ducts, vents, and blowers based on flow rates, friction loss and other data.
-- Calculate heat loss/gain in plumbing and duct systems.
-- Maintain and repair solar plumbing.

*From Solar Technicians and Mechanics, a Preliminary Occupational Analysis

by Southwest Energy Management, Inc, 7283 Engineer Rd., Suite G, San Diego, CA 92111

TABLE 2

PREDOMINANT SOLAR MECHANIC TASKS*

Solar Mechanic Task Requirement
-- Install and wire solar control systems.
-- Read blueprints and/or schematics.
-- Cut and join plastic pipe/plumbing.
-- Install solar collectors on existing roofs.
-- Maintain and repair solar collector array.
-- Maintain and repair solar plumbing.
-- Maintain and repair solar blowers and fans.
-- Cut and braze copper pipe/tubing.
-- Install prefabricated sheet metal parts.
-- Install solar collector array or solar furnace at ground level.
-- Maintain and repair solar water pumps.
-- Install water storage sub-systems.
-- Install living area/space heat exchanger units.
-- Build and/or install rock storage sub-systems.
-- Install solar-pond or solar-wall (thermal mass) systems.
-- Soft-solder electrical wires and connections.
-- Install auxiliary back-up heating systems.
-- Modify existing furnace to accept solar apparatus.
-- Cut and/or install glass or plastic glazing in collectors.
-- Install movable insulation and apparatus in passive systems.
-- Modify or relocate existing plumbing and exhaust vents on roof.
-- Install heating ducts and vents.
-- Install solar-assisted heat pumps.
-- Trouble-shoot, maintain and repair solar controls.
-- Silver braze copper alloy pipe and sheets.
-- Cut, bend, fabricate sheet metal parts.
-- Perform supervisory functions.
-- Cut, thread, install galvanized pipe/plumbing.

*From Solar Technicians and Mechanics, a Preliminary Occupational Analysis

by Southwest Energy Management, INc, 7283 Engineer Rd, Suite G, San Diego, CA 92111

TABLE 3.

Community College of Denver
Red Rocks Campus

SOLAR ENERGY-INSTALLATION & MAINTENANCE
(Certificate or Associate Degree)

The program is designed to provide the student with the knowledge and skills for job entry into the solar energy field, in the area of installation and maintenance, and to provide upgrading and refresher courses for people already employed in the field.

Required Major Courses

Course No.		Title	Credit Hours	Contact Hours
SOM	220	Basic Solar Systems	3	60
SOM	221	Solar Engineering Technology I	4	68
SOM	222	Solar Engineering Technology II	4	68
SOM	225	Solar System Design & Layout	3	60
SOM	226	Solar Panel Arrays	3	60
SOM	227	Domestic Hot Water	3	60
SOM	228	Solar System Maintenance	3	60
SOM	229	Solar Panel Installations	3	60
SOM	235	Basic Solar Controls	3	60
SOM	236	Advanced Solar Control Systems	3	60
SOM	237	Passive Solar Systems	3	60
SOM	238	Alternative Backup Systems for Solar Energy	3	60
SOM	239	Introduction to Photovoltac & Wind Energy	3	60
PLU	100	Orientation of Tools, Basic Plumbing, & Drawings	3	60
PLU	107	Water Piping Methods	3	60
PLU	206	Hot Water Heating-Installation & Maintenance	3	60
BRI	120	Bricklaying For Construction Trades	3	60
BTR	125	Blueprint Reading For Construction Trades	4	68
CAR	120	Carpentry For Construction Trades	3	60
SHM	100	Basic Sheet Metal For Solar Energy	3	60
SHM	101	Advanced Sheet Metal For Solar Energy	3	60
			66	1284

Required Related Courses

	Math Elective	3	45
	English Elective	3	45
	Social Science Elective	3	45
	Electives	2	30
		11	165
		77	1449

Additional Major Courses

SOM	297	Cooperative Work Experience	2-9	60-375
SOM	299	Independent Study	3	68

TABLE 4. PROPOSED CURRICULUM OUTLINE - SOLAR ENGINEERING TECHNICIAN

	CREDIT HOURS	CONTACT HOURS (Lecture-Lab Hours)
FIRST SEMESTER		
1. Math I	3	3
2. Energy Science	4	6 (3-3)
3. Introduction to Solar Energy - Conservation & Passive Design	2	2
4. Materials & Material Handling	3	5 (1-4)
5. Engineering Drawing	3	3
6. Education & Career Planning	1	1
	16	20
SECOND SEMESTER		
1. Math II	3	3
2. Energy Science	4	6 (3-3)
3. Collectors & Energy Storage	4	6 (2-4)
4. HVAC	4	6 (2-4)
5. English	3	3
	18	24
THIRD SEMESTER		
1. Applied Electrical Circuits & Instrumentation	4	6 (2-4)
2. Sizing Design & Retrofit	4	6 (3-3)
3. Technical Survey of Energy Sources	3	3
4. Introduction to Computers & Computer Programming	3	3
5. Introduction to Business	3	3
	17	21
FOURTH SEMESTER		
1. Operational Diagnosis	3	5 (2-3)
2. Codes, Legal, Economic, Consumerism	2	2
3. General Psychology and/or Human Relations in Industry	3	3
4. Non-residential Applications & Future Technology	3	5 (2-3)
5. Technical Report Writing	2	2
6. Solar Practicum	3 - 5	
	13 + prac.	17 + prac.

SCOTT COMMUNITY COLLEGE
Bettendorf, Iowa
Curriculum for
SOLAR ENERGETICS TECHNOLOGY
July 12, 1978

TABLE 5

Course No.	Course Title	Credits	Clock Hrs.
QUARTER I			
80-111	Basic Refrigeration Fundamentals	6	120
80-112	Basic Electrical Fundamentals	6	120
28-101	General Mathematics I	3	36
24-115	Communications Skills I	3	36
80-113	Soldering & Brazing	2	48
		20	360
QUARTER II			
80-121	Electrical Controls & Circuitry	6	120
80-122	Refrigeration Components	4	84
28-102	General Mathematics II	3	36
80-125	Fundamentals of Air Flow	6	120
		19	360
QUARTER III			
80-133	Domestic Heating & Air Conditioning	6	120
80-135	Blue Print Reading	3	60
80-142	Commercial Refrigeration Principles	6	120
81-100	Sheetmetal Fundamentals	3	60
		18	360
QUARTER IV			
28-121	Applied Mathematics II	4	60
81-114	Intro. to Solar Heating & Cooling	3	60
80-143	Commercial Refrigeration Systems	6	120
60-101	Physics I (Heat & Insulation)	4	84
81-115	Human Relations	3	36
		20	360
QUARTER V			
28-131	Technical Mathematics I	4	60
60-112	Engineering Drafting I	4	108
81-258	Computer Programming	3	60
60-102	Physics II (Statics & Fluids)	4	72
62-258	Industrial Electronics	3	60
		18	360

TABLE 5: (Continued - Scott Community College)

QUARTER VI

28-241	Technical Mathematics II	4	60
81-261	Solar System Analysis	6	120
60-103	Physics III (Optics)	3	60
62-268	Microprocessor Control Fundamentals	6	120
		19	360

QUARTER VII

81-265	Energy Economics	6	120
81-251	Graphics	6	132
81-281A	Design Project-Phase A	5	108
		17	360

QUARTER VIII

81-281B	Design Project-Phase B	6	132
24-125	Communications Skills II	3	48
81-252	Related Solar Concepts	5	120
81-284	Business Organizations & Management	4	60
		18	360

TABLE 6. Equipment List
Clark County Community College

supplied by David Comarow

	Price
Instrumentation	
Flow meters, strip chart recorder	$2500
Calculator, with Software	575
6 Computer Terminals	7100
Hand Tools	2700
Simulators*	
Controller Bread Board Trainer 2 Modular Liquid System Trainers (MLST) 2 Central Control Monitoring Packages (CCMP)	38000
Collector Arrays and Installation - 5 collectors	6400
	$57,275

In addition to the above equipment, Clark County Community College paid $12,000 to the Desert Research Institute for a needs assessment study, a program assessment study, and the development of three computer programs used in the training program.

*The Simulators were built by Desert Research Institute at cost.

TABLE 7. Community College of Denver
Red Rocks Campus
Solar Energy Installation & Maintenance Program

Instruments:	Cost
2 Heliotrope General Strip Chart Recorders, Model SCR-10	$780.00
2 Heliotrope General Electronic Thermometer, Model ET10	258.00
1 Heliotrope General Thermometer, Model ET/DT3	96.00
1 Heliotrope General Thermometer, Model HH-230	83.00
Assortment of Heliotrope General Sensors	100.00
1 Texas Instrument TI-59 Programmable Calculator	270.00
1 Printer for above calculator, Model PC-100A	180.00
1 Hastings Air Meter, Model 6-11	150.00
1 Extension cable for above meter, Model CF-12-CM	14.00
1 T.I.P. Volume-Aire Air Balancer, Model VA-105	100.00
1 Rio Sigma Photovoltaic Pyranometer, Model RS1008	135.00
1 Rio Sigma Single Track Recorder for above, Model RS1009	280.00
2 Heliotrope General Electronic Thermometers, Model ETO/350	200.00
Heliotrope General TES-1 Sensors	100.00
1 Meter-Master Digital Multimeter, Model 461	150.00
Sub-total	$28,960.00

Equipment:	
1 Grumann Domestic Hot Water Package Model 60FFT	1150.00
2 Grumann double glazed collectors, Model 60F	550.00
8 Sungrabber 2'x10' Collectors with Black Chrome (Rocky Mountain Products, Denver)	2500.00
1 Domestic Hot Water System, Lordan Collectors, Mountain Mechanical Sales, Denver (three)	1156.00
2 Solaron Air Collectors plus mounting hardware, Model CL 2003X, Capture Energy Products, Inc. Denver, Co.	1175.00
2 Solaron Air Collectors plus mounting hardware, Model CL 2003Y, Capture Energy Products, Inc. Denver, Co.	1175.00
1 Solar Air Handling Unit with thermostate and controls	300.00
5 Misc. Delta T's and other components	500.00
1 80 Gal. Sepco Storage tank with removable heat exchanger, Capture Energy Products, Inc. Denver, CO.	504.00
1 Domestic Hot Water System, including 2 Insolarator Collectors, Model #SA120-1255, Mountain Mechanical Sales, Denver, CO	1100.00
Subtotal	$10,110.00

Miscellaneous:

Miscellaneous such as hand tools; pumps; torches; welding equipment; ½ POWER collector glazings; copper sheets; piping and ducting materials; insulation; selective surface material; demonstration equipment, etc. $8000.00

Grand Total $21,006.00

TABLE 8. Equipment List - Navarro College

This equipment list, which specifically references certain manufacturers and distributors, is meant to be typical of what is available, and not necessarily the equipment to be purchased.*

Closed Loop Domestic Hot Water System

1	Lennox "Solar Mate" Hot Water System - 3 Collectors (double glazed) including pump, proportional flow controller, expansion tank, storage tank with heat exchanger (82 gallon), and tempering valve	$1760
1	Similar system except with single glazed collectors	1650
2	Flow meters (approximately $90 each)	180
	TOTAL FOR SYSTEMS	$3590

Complete Solar Systems

Minimum sized operational liquid and air systems.

Air System Equipment

Collectors - 200 square feet (Solaron - $16.50 per square foot)	$ 3,300
Insulated Air Ducting - 200 feet ($3.50 per foot)	700
Solar Air Mover, including differential thermostat, blower and motorized dampers (Solar Control Corp. including 25% educational discount)	1,195
Solarstat Solid State Solar System Monitor (Solar Control Corp. including 25% educational discount)	230

TABLE 8. (continued)

Domestic Hot Water Sub-Assembly, including air-water heat exchanger, circulating pump, and storage tank	*330*
Energy Storage System, rockbed, 200 cubic feet, 5'x5'x8' high. Constructed on-site. Includes: plywood and lumber, insulation, rock.	*500*
Water System Equipment	
Collectors - 200 Square feet (Numerous manufacturers, $16.50/sq.ft.)	*$ 3,300*
Insulated Piping - 200 feet @ $2.00 per foot	*400*
Circulating Pumps, 2 (Grundfos Pump UPS20-42-F - $75.00)	*150*
Storage Tank, 600 gallon, low pressure	*660*
Solenoid Valves (Skinner 4 @ $45.00 each)	*180*
Differential Controller (Hawthorne Variflow H-1510)	*70*
Liquid-Liquid Heat Exchanger, 2 (one for collector loop, one for providing heat load to system $440.00 each)	*880*
Liquid-Air Heat Exchanger with Blower	*440*
Anti-freeze, 10 gallons @ $4.00 per gallon	*40*
SUBTOTAL	*$12,375*
Solar Meterological Data Instrumentation	
Solar Tracker, model ST-1	*$ 820*
Eppley Normal Incidence Pyrheliometer, with clear glass, model 650	*980*
Eppley Precision Spectral Pyranometer, with clear glass, model 646	*1,090*
Dual Channel Printout System, with synchronous tempotec timer, model 618-3DCP	*2,250*
Panel Digital Voltmeter	*200*
Recording thermograph, model #151-1, Science Associates, Inc.	*270*
Princeton Wind Set #414, Science Associates, Inc.	*220*
SUBTOTAL	*$ 5,830*

TABLE 8. (continued)

Solar Collector	
Used for gaining working experience with different types of collectors.	
Forty square feet each of three different liquid collectors at $15.00 per square foot	$ 1,800
Modular Collector Kits (New Jersey Aluminum, $660.00 each)	1,320
Changeable Absorber Plates for Modular Collectors, copper roll bond, 2 (Kalwall Corp., $88.00 each)	176
Aluminum Roll Bond, 2 (Kalwall Corp., $55.00 each)	110
Flat Aluminum for Air Systems, 2 (Kalwall Corp., $30.00 each)	60
Circulating Pumps, 2 (Kalwall Corp., Teel pump - $55.00)	110
Air Blower, 2 (Kalwall Corp., Dayton K4C013 - $28.00)	56
Miscellaneous Materials, including sealant, tubing, ducting, insulation, etc.	250
Flowmeters, 2 (Wallace & Tiernan, model 5510A0-1-2-06 - $90.00)	18
Various Glazing Materials, including glass and fiberglass	250
Three Focusing Tracking Collector Units, with tracking mechanisms (Northrup, Inc.)	1,100
Six Parabolic Non-tracking Focusing Units (White Line Corp., $110 per unit)	660
Mounting Materials for All Collectors	850
SUBTOTAL	$ 6,922
Thermal Storage	
Liquid Storage System, including steel and concrete drums, supports and insulation	$ 450
Air Storage System, including plywood, lumber, insulation rocks, etc.	450

TABLE 8. (continued)

Latent Heat Storage System, including plywood, insulation, heat storage trays, and fused salts	*900*
SUBTOTAL	*$ 1,800*

Instrumentation Support Equipment Special to Solar Technology

Hot Wire Anemometer (Science Associates, Inc. #447(1)-1)	*$ 450*
Digital Thermometer with External Thermistor Probe, 5 (Electrometics, $140 each)	*700*
Thermistor Sensors, 30 (Electrometics, $12.00 each)	*360*
Thermistor Switch Box (Electrometics)	*25*
Thermistor Hook-up Wire, 3,000 feet (Radio Shack, $0.10 per foot)	*300*
Flowmeters, 3 (Wallace & Tiernan, model 5510AO-1-2-06, $93.00)	*279*
SUBTOTAL	*$ 2,114*

Solar System Simulators

Simulators are extremely useful for teaching principles before the student experiments on the real equipment. This type of simulator is completely interactive, permitting the teacher to familiarize the student with the effect of varying numerous solar parameters. Twenty-four major system malfunctions can be inserted by the teacher to introduce the student to trouble-shooting.

Solar System Simulators (Omnidata, Inc. model 327)	*$ 6,385*
Printer Drawer Interface (Omnidata PDI-1)	*252*
Student Tracking Printer (Omnidata, STP)	*875*
SUBTOTAL	*$ 7,512*

Calculators

Many of the sizing and design calculations are being carried out on small, programmable calculators. There are several companies making available pre-

TABLE 8. (continued)

written program cards for solar sizing and design calculations. Calculators of this type are not standard equipment at most colleges.

Programmable Calculator, 2 (Texas Instruments, Model 59 - $253.00)	$ 506
Printer for Calculator, 2 (Texas Instruments, model PC-100A - $176.00)	352
Programmable Calculator with printer, 2 (Hewlett-Packard, Model 97 - $710.00)	1,420
SUBTOTAL	$ 2,278
Shipping estimate for above items:	2,500
TOTAL LABORATORY COSTS	$44,921

In addition, one could spend another $6,000 on solar refrigeration equipment and $2,000 on photovoltaic equipment. As well, there will be construction costs incurred for installation of outdoor demonstrations. Navarro College has estimated such costs to be around $8,500.

TABLE 9. SCOTT COMMUNITY COLLEGE
SOLAR ENERGETICS TECHNOLOGY EQUIPMENT LIST

ITEM	QTY.	DISTRIBUTOR	COST Unit	COST Total
Alnor Velometer	1	Dennis Co.		453.20
Solar System Trainer AP-3	1	Lennox		2,500.00
ST-17 Solar Heat Service Trainer	1	Lennox		1,500.00
GB 5 Solar Schematic Trainer	1	Lennox		700.00
Solar Panels Complete	1	Solaron		6,347.81
Solar Aire Demo System w/collectors	10	Illowa Solar		6,620.00
Air Control Unit. Storage Package (1500 trays). Installation manual				
FV2 Flo Vu Water Table	1	Lennox		795.00
RT5 Solar Cycle Trainer	1	Lennox		700.00
EB3 Heat-Cool Schematic Elec.	1	Lennox		495.00
EB2 Heat-Cool Schematic Oil	1	Lennox		495.00
RT-3 Heat Pump Cycle Tr.	1	Lennox		695.00
EB-4 Heat Pump Schematic Tr.	1	Lennox		750.00
ST-1A Potential Relay Tr.	1	Lennox		360.00
ST-2 Basic Electricity Tr.	3	Lennox	350.00	1,050.00
ST-4 Gas Heat Service Trainer	3	Lennox		1,195.00
ST-7 Direct Spark Ignition Tr.	1	Lennox		795.00
ST-9 Heat Pump Service Trainer	1	Lennox		1,295.00
ST-17 Solar Heat Service Trainer	1	Lennox		1,500.00
BT-1 Bi Metal Trainer	1	Lennox		495.00
GT-1 Gas Fundamentals Trainer	1	Lennox		440.00
OT-1 Oil Fundamentals Trainer	1	Lennox		415.00
OT-2 Cad Cell Trainer	3	Lennox	150.00	450.00
OT-3 Oil Burner Trainer	1	Lennox		580.00
OT-4 Oil Pump Trainer	1	Lennox		350.00
MIP-7 Flue and Chimney Trainer	3	Lennox	85.00	255.00
MIP-8 Plastic House Trainer	3	Lennox	165.00	495.00
AP-2 Air Distribution System Tr.	2	Lennox	995.00	1,990.00
AP-5 Hydronic Principles Trainer	1	Lennox		795.00
SHW-2 Domestic Water Heater - solar	1	Lennox		1,450.00
LE-8 Solar Test Equipment	1	Lennox		1,880.00
LE-4 Basic Test Equipment	1	Lennox		1,195.00
322 Electric Home Alc.	1	Omnidata Inc.		3,615.00
STP Student Tracking Printer	2	Omnidata Inc.	705.	1,410.00
326 Heat Pump Technology	1	Omnidata Inc.		4,198.00
327 Solar Energy Simulator	1	Omnidata Inc.		5,833.00
			Total	$54,092.01

REFERENCES

1. "Solar Heating and Cooling of Residential Buildings: Sizing, Installation and Operation of Systems", prepared by the Solar Energy Applications Laboratory, Colorado State University, Fort Collins, Colorado, January 1977. Available from Superintendent of Government Documents, US Government Printing Office, Washington, DC 20402, S/N 003-011-00085-2. Price: $7.50

2. "Solar Heating and Cooling of Residential Buildings: Design of Systems", prepared by the Solar Energy Applications Laboratory, Colorado State University, Fort Collins, Colorado, January, 1977. Available form Superintendent of Government of Government Documents, US Government Printing Office, Washington, DC 20402, S/N 003-011-00084-4. Price: $8.25

BIBLIOGRAPHY

SOM 220, 225, & 226:

Anderson, B. and Riordan, M., The Solar Home Book: Heating, Cooling and Designing with the Sun. Cheshire Books, Harrisville, New Hampshire, 1976.

SOM 227, 228, & 229:

Montgomery, Richard, The Solar Decision Book: Your Guide to Making a Sound Investment. Dow Corning Corporation, Midland, Michigan, 1978.

SMACNA, Fundamentals of Solar Heating, Sheet Metal and Air Conditioning Contractors National Association, Vienna, Virginia, 1978.

SOM 221 & 222:

Winn, B., Karaki, S., Lof, G., et al. Solar Energy Applications Laboratory, Colorado State University. Solar Heating and Cooling of Residential Buildings: Design of Systems. U.S. Government Printing Office, Oct. 1977.

Ward, D., Karaki, S., Lof, G., et al. Solar Energy Applications Laboratory, Colorado State University. Solar Heating and Cooling of Residential Buildings: Sizing, Installation and Operation of Systems. U.S. Government Printing Office, Oct 1977.

ITT. Solar Heating Systems Design Manual. International Telephone and Telegraph Corporation, Training & Education Dept. Fluid Handling Division, Morton Grove, Illinois, 1977.

U.S. Dept. of Housing and Urban Development. Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems. U.S. Government Printing Office, 1977.

SOM 235 & 236:

Miles, V.C., Thermostatic Control Principles and Practice. Butterworth & Co., 88 Kingways, London, England. 1965.

(Forthcoming - Publication Date Dec. 1978): Farber, Joseph, Controls and Pumps for Solar Heating and Cooling. Publishing Office of the American Section of the International Solar Energy Society, Newark, Delaware. Dec. 1978.

SJM 237:

Prowler, Don, ed., Proceedings of the 1978 Passive Solar Conference, Philadelphia, PA., March 1978. Mid-Atlantic Solar Energy Association, Philadelphia, PA. 1978

(Forthcoming - Publication Date Oct. 1978): Cook, Jeffrey, Passive Systems '78, Publishing Office of the American Section of the International Solar Energy Society, Newark, Delaware. Oct. 1978.

Stromberg, R.P., and Woodall, S.O., Passive Solar Buildings: A Compilation of Data and Results. National Technical Information Service, Springfield, VA. August, 1977.

Kroner, Walter and Haviland, David, Passive Design Ideas for the Energy Conscious Builder. A National Solar Heating and Cooling Information Center Publication, Rockville, MD. 1978.

- Students are provided with handout materials in each class. Memberships in the International Solar Energy Society and the Colorado Solar Energy Society are encouraged along with subscriptions to such magazines as Solar Age, Solar Engineering and Solar Heating & Cooling. -

CODE INFORMATION USED IN CLASSROOM:

IAPMO. Uniform Solar Energy Code, 1976 Edition. International Association of Plumbing and Mechnical Officials, Los Angeles, Calif. Sept. 1976.

IAPMO. Uniform Plumbing Code, 1976 Edition. International Association of Plumbing and Mechnical Officials, Los Angeles, Calif. Jan. 1977

SMACNA. Installation Standards For One and Two Family Dwellings and Multifamily Housing Including Solar. Sheet Metal and Air Conditioning Contractors National Association, Vienna, Virginia. Jan. 1978.

State of Colorado, Office of State Planning and Budgeting and the Department of Local Affairs. State of Colorado Energy Conservation Standards. Colorado Division of Housing, Denver, Co. Nov. 1977.

APPENDIX II

SOURCES OF INFORMATION

The references sources on the following pages are the results of the compilation of The National Solar Heating and Cooling Information Center. The items marked with an asterisk are those suggested as items to start your reading if you haven't done so. This is not meant to be a reflection of judgement on the quality of the other listed references, only a guide to choose from on a long list of references.

As an operational example of the material suggested for students' use in technical training programs, see Appendix I.

For possible funding sources, one should obtain a copy of "A Selected Guide to Federal Energy and Education Assistance," Energy and Education Action Center, U.S. Office of Education, Room 514, Reporters Building, 300 7th Street, S.W., Washington, DC 20202. Phone (202) 472-7777.

NATIONAL SOLAR HEATING AND COOLING INFORMATION CENTER
P. O. BOX 1607
ROCKVILLE, MD 20850
CALL TOLL FREE (800) 523-2929
IN PENNSYLVANIA CALL (800) 462-4983

READING LIST FOR SOLAR ENERGY

DC 107
7th edition
March 1978

NON-TECHNICAL

THE BUY WISE GUIDE TO SOLAR HEAT...F. Hickok; Hour House, P.O. Box 40082, St. Petersburg FL 33743, 1976, 121 pp, $9.00. The consumer's guide to solar heating and cooling; what to buy, what to do, what to beware of.

THE COMING AGE OF SOLAR ENERGY...D. S. Halacy, Jr.; Harper and Row, Inc., New York NY 10022, 1973, 231 pp, $7.95. Interesting for its historical treatment of solar energy.

*DIRECT USE OF THE SUN'S ENERGY...F. Daniels; Ballantine Books, Inc., Westminster MD 21157, 1964, 271 pp, $1.95. Covers all aspects of solar research and application; provides a general introduction to the subject.

HANDBOOK OF SOLAR AND WIND ENERGY...F. Hickok; Cahners Books International, Inc., Boston, MA, 1975, 125 pp, $20.00. Overview of the state-of-the-art in solar heating and cooling and other solar technologies.

HARNESSING THE SUN TO HEAT YOUR HOUSE...J. Keyes; Morgan and Morgan, Dobbs Ferry, New York 10522, 1974, 192 pp, $2.95. Provides basic introduction to solar heating applications in understandable language; includes comprehensive index of more technical data.

HOME IMPROVEMENTS FOR CONSERVATION AND SOLAR ENERGY...F. Hickok; Hour House, St. Petersburg FL 33743, 1977, 151 pp, $6.80. Concerned with retrofitting a house so that it is more energy-effcient; includes solar.

HOMEOWNER'S GUIDE TO SOLAR HEATING AND COOLING...W. H. Foster; Tab Books, Blue Ridge Summit PA 17214, 1976, 196 pp, $4.95. Covers the basics of solar heating along with practical advice for consumers.

HOW TO BUILD A SOLAR HEATER...T. Lucas; Ward Ritchie Press, Pasadena CA 91103, 1975, 236 pp, $4.95. Guide to building and buying solar collectors, water heaters and pool heaters; includes list of manufacturers, bibliography, and glossary.

HOW TO USE SOLAR ENERGY IN YOUR HOME AND BUSINESS...T. Lucas, Ward Ritchie Press, Pasadena CA 91105, 1977, 250 pp, $7.95. Practical, basic guide to building and buying solar collectors; includes glossary, bibliography, and list of manufacturers.

*SOLAR AGE CATALOG...S. Oddo (ed); Solar Age, Church Hill, Harrisville NH 03450, 232 pp, $8.50. Compilation of articles on all aspects of solar heating; includes comparative data tables of various types of collectors.

SOLAR HOMES AND SUN HEATING...G. Daniels; Harper and Row, Inc., New York NY 10022, 1976, 178 pp, $8.95. Practical guide to solar heating for the layman; presents a non-technical description of basic principles, existing systems and techniques for construction and installation.

SUN POWER: AN INTRODUCTION TO THE APPLICATIONS OF SOLAR ENERGY...J. C. McVeigh; Pergamon Press, Elmsford, NY 10523, 1977, 208 pp, $4.95. This state-of-the-art publication is written in non-technical language; all aspects of solar covered.

THE CENTER IS OPERATED BY THE FRANKLIN INSTITUTE RESEARCH LABORATORIES FOR THE US DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT AND THE US DEPARTMENT OF ENERGY. THIS LIST CONTAINS NAMES THAT WERE KNOWN TO THE CENTER AT THE TIME OF PRINTING. SINCE THE CENTER DOES NOT EVALUATE PRODUCTS OR SERVICES THE APPEARANCE OF NAMES ON THIS LIST DOES NOT INDICATE ENDORSEMENT, NOR DOES THE ABSENCE INDICATE DISAPPROVAL. PERIODIC UPDATES ARE AVAILABLE. IF YOU WISH TO BE LISTED, PLEASE CONTACT US.

NON-TECHNICAL CONT'D

SURVEY OF THE EMERGING SOLAR ENERGY INDUSTRY...J. A. Berney; Solar Energy Information Services, P.O. Box 204, San Mateo CA 94401, 1977, 405 pp, $60.00. A comprehensive listing of names and addresses related to the solar industry; also an overview of the different facets of the industry.

TECHNICAL

*APPLICATION OF SOLAR ENERGY FOR HEATING AND COOLING OF BUILDINGS...R. C. Jordan and B. Y. H. Liu (eds); ASHRAE (Sales Dept), 345 E. 47th St., New York NY 10017, 206 pp, $9.00. Compilation of technical articles on the assessment, components, performance, and application of solar energy for heating and cooling; includes references, charts, and index.

APPLIED SOLAR ENERGY: AN INTRODUCTION...A. A. Meinel and M. P. Meinel; Addison-Wesley Publishing Co., Reading MA 01867, 1976, 651 pp, $17.95. Basic textbook introduction to the theory of solar energy; intended for college seniors or graduate students.

BASICS OF SOLAR HEATING AND HOT WATER SYSTEMS...AIA Research Corp., Washington, D.C. 20006, 1977, 48 pp, $5.00. Discusses design considerations important to the total system.

SOLAR COLLECTOR DESIGN...D. K. Edwards; Franklin Institute Press, Philadelphia, 19103, 1977, 64 pp, $8.50. Technical in nature, this discusses the specifics in construction and design of solar components.

SOLAR ENERGY FOR MAN...B. J. Brinkworth; John Wiley & Sons, Inc., Somerset NJ, 1972, 251 pp, $9.95. Comprehensive, technical treatment of the practical uses of solar energy.

SOLAR ENERGY, TECHNOLOGY AND APPLICATIONS...J. R. Williams; Ann Arbor Science Publications, Inc., Ann Arbor MI 48106, 1977, 120 pp, $6.95 (soft cover). Definitive overview of the various techniques for utilizing solar energy; includes glossary and comprehensive bibliography. Supplemented by the 1976 Solar Update which covers new developments since 1974.

*SOLAR ENERGY THERMAL PROCESSES...J. A. Duffie and W. A. Beckman; John Wiley and Sons, Inc., New York NY 10016, 1974, 386 pp, $18.00. How to understand and predict the performance of solar collectors and solar photothermal systems for heating and cooling buildings and for heating water and air; comprehensive and coherent treatment for professionals, and especially for engineers.

*SOLAR HEATING AND COOLING: ENGINEERING, PRACTICAL DESIGN, AND ECONOMICS...J. F. Kreider and F. Kreith; McGraw-Hill Book Co., New York NY 10036, 1975, 342 pp, $24.75. Designed as a how-to handbook with emphasis on economically feasible heating and cooling systems; contains considerable technical detail and extensive tables of reference data.

*SOLAR HEATING DESIGN BY THE F-CHART METHOD...W. A. Beckman et al; John Wiley & Sons, New York NY 1977, 200 pp, $14.95. Describes a practical method for sizing solar space and water heating systems.

SOLAR HEATING SYSTEMS DESIGN MANUAL...International Telephone and Telegraph Corporation, Fluid Handling Division, 4711 Golf Rd., Skokie IL 60076, 1976, c100 pp, $2.50. Brings together technical data, procedures, and designs necessary to install a solar hydronic heating system; based on system installed at ITT's training facility in Morton Grove.

ARCHITECTURAL

ARCHITECTURE AND ENERGY... R. G. Stein; Doubleday, Garden City NY 11530, 1977, 322 pp, $12.95. This outlines the problems with today's architecture and explains how to conserve energy through better design of buildings.

THE COMPLETE SOLAR HOUSE...B. Cassiday; Dodd, Mead & Co., New York NY 10016, 1977, 212 pp, $8.95. Discusses workings and functions of solar energy systems; also the cost-saving features.

DESIGN FOR A LIMITED PLANET...N. Skurka and J. Naar; Ballantine Books, New York NY 10022, 1976, 215 pp, $5.95. Descriptions and photographs of 35 solar houses.

*DESIGNING AND BUILDING A SOLAR HOUSE...D. Watson; Garden Way Publishing, Charlotte VT 05445, 1977, 240 pp, $8.95. Practical, clearly-written book which covers all aspects of solar house design, including siting, equipment, different types of systems, and costs.

*SOLAR ARCHITECTURE...G. E. Franta and K. R. Olson; Ann Arbor Science Publisher, Ann Arbor MI 48106, 1977, 331 pp, $15.00. Proceedings of a forum on energy concerned with solar architecture, especially passive designs.

SOLAR ENERGY AND BUILDING...S. V. Szokolay; John Wiley and Sons, New York NY 10016, 1975, 148 pp, $18.50. Provides a conceptual understanding of the problems and solutions of solar energy: contains an illustrated architectural review of "solar houses" including plans and performance data.

SOLAR ENERGY FOR PACIFIC NORTHWEST BUILDINGS...J. S. Reynolds; University of Oregon, Eugene OR, 1976, 64 pp, $7.00. Useful in other areas than the Pacific Northwest: presents solar data, system sizing, and collector information.

*SOLAR ENERGY: FUNDAMENTALS IN BUILDING DESIGN...B. Anderson; McGraw Hill Co., New York NY 10036, 1977, 374 pp, $21.50. More technical version of the Solar Home Book; designed for architects and building professionals.

SOLAR ENERGY HOME DESIGN IN FOUR CLIMATES...Total Environmental Action, Harrisville NH 03450, 1975, 198 pp, $11.75. Contains architectural designs with floor plans for solar houses in four areas of the U.S. Includes analysis of climatic data and their effect on the design process.

*SOLAR HEATED BUILDINGS: A BRIEF SURVEY (13th edition)...W. A. Shurcliff; 19 Appleton St., Cambridge MA 02138, 1977, 306 pp, $12.00 prepaid. Contains descriptions of 319 buildings which are partially or fully solar heated; includes buildings that did exist, do exist or are expected to exist very soon. Permits comparison of characteristics and performances of a wide variety of solar heated buildings.

SOLAR HEATED HOUSES FOR NEW ENGLAND AND OTHER NORTH TEMPERATE CLIMATES...Massdesign, 138 Mt Auburn St., Cambridge MA 02138, 1977, 68 pp, $7.50. Three house designs, with computer performance data are discussed; climatic information included for New England.

*SOLAR HOME BOOK...B. Anderson and M. Riordan; Cheshire Books, Harrisville NH 03450, 1976, 297 pp, $7.50. Covers various aspects of solar home heating including direct and indirect systems, do-it-yourself solar water heating, retrofitting and social and cultural implications.

SOLAR PRIMER ONE...B. Carlson; SOLARC, Whittier CA 90607, 1975, 101 pp, $10.95. Written by architects; presents basic solar applications and building design with discussions of collectors, structure, heat transfer, storage and total heating and cooling systems.

*SUN-EARTH...R. L. Crowther, et al; Crowther/Solar Group, Denver CO 80206, 1976, 232 pp, $12.95. A survey of architecture and its relation to the natural environment; presents cost effective concepts for use of free, natural energy sources in homes and other buildings.

THIRTY ENERGY EFFICIENT HOMES YOU CAN BUILD...A. Wade and N. Ewenstein; Rodale Press, Emmaus PA 18049, 1977, 316 pp, $8.95. Designs of houses already constructed are presented for use by people building their own homes; designs utilizing solar are included.

GENERAL ENERGY

*ENERGY BOOK #1 and #2: NATURAL SOURCES AND BACKYARD APPLICATIONS...J. Prenis (ed); Running Press, Philadelphia PA 19103, 1975, 112 pp, $4.00. (BOOK #2-1977, 125 pp, $5.00). Review of possible alternative sources of energy; short descriptions of different ideas and designs.

ENERGY FOR SURVIVAL...W. Clark; Doubleday and Co., Inc., New York NY 11530, 1974, 652 pp, $4.95. Energy sources in the past, present, and prospects for the future: major section on solar energy.

GENERAL ENERGY CONT'D

ENERGY PRIMER...Portola Institute; Whole Earth Truck Store, 558 Santa Cruz Ave., Menlo Park CA 94025, 200 pp $5.50. A comprehensive book about renewable sources of energy - solar, water, wind, and biofuels. The focus is on small-scale systems which can be applied to the needs of the individual, small group, or community.

ENERGY WE CAN LIVE WITH...D. Wallace; Rodale Press, Emmaus PA 18049, 1976, 150 pp, $3.95. Analyzes the potentials and applications of alternative energy sources, including solar energy; solutions for the energy problems by working with nature.

HANDBOOK OF HOMEMADE POWER...The Mother Earth News; Bantam Books, New York NY 10019, 1974, 374 pp, $2.25. Combination of reprint and original articles on using various energy sources including solar energy. Includes instructions on how to build and use solar cookers, ovens, heaters and water heaters; extensive bibliography.

HOME ENERGY HOW-TO...A. J. Hand; Harper and Row, New York NY 10022, 1977, 258 pp, $9.95. Complete guide to saving and producing home energy.

HOMEOWNER'S GUIDE TO SAVING ENERGY...B. L. Price and J. T. Price; Tab Books, Blue Ridge Summit PA 18214, 1976, 288 pp, $5.95. How to save money on home heating, cooling, appliance and electricity costs.

HOMEOWNER'S ENERGY GUIDE...J. A. Murphy; Thomas Y. Crowell Co., New York NY 10003, 1976, 215 pp, $6.95. Workbook format enables the homeowner to compare the relative costs and savings of various energy conserving measures.

LOW-COST ENERGY-EFFICIENT SHELTER FOR THE OWNER AND BUILDER...E. Eccli (ed); Rodale Press, Inc., Emmaus PA 18049, 1976, 408 pp, $5.95. Covers the basics involved in owning and building an energy-efficient home; includes solar applications.

*OTHER HOMES AND GARBAGE: DESIGN FOR SELF-SUFFICIENT LIVING...J. Lecki et al; Sierra Club Books, Washington, D. C. 20003, 1975, 302 pp, $9.95. Emphasizes renewable energy sources with a chapter on solar heating; presents methods for self-sufficient living.

THE POVERTY OF POWER: ENERGY AND THE ECONOMIC CRISIS...B. Commoner; A. Knopf, New York NY 10022, 1974, 320 pp, $2.75. The energy crisis as seen by an environmentalist; covers government and industrial opposition to alternative energy sources and recommendations for the future.

PRODUCING YOUR OWN POWER...C.H. Stoner (ed.); Rodale Press, Inc., Book Div., Emmaus PA 18049, 1974, 322 pp, $8.95. Handbook on how to calculate energy needs, conserve energy in existing structures, and locate required equipment.

SMALL IS BEAUTIFUL; ECONOMICS AS IF PEOPLE MATTERED...E. Schumacher, Harper & Row, New York NY 10022, 1974, 320 pp, $8.95. Philosophical view of the world's social and economic problems including energy; offers some smaller-scale yet feasible solutions to these problems.

*SOFT ENERGY PATHS: TOWARDS A DURABLE PEACE...A. R. Lovins, Ballinger Publishing Co., Cambridge MA, 1977, 234 pp, $6.95. Proposes a restructuring of our energy system and steps to putting renewable energy into action.

DIRECTORIES

INFORMAL DIRECTORY OF THE ORGANIZATIONS AND PEOPLE INVOLVED IN THE SOLAR HEATING OF BUILDINGS (3rd edition)...W. A. Shurcliff; 19 Appleton St., Cambridge MA 02138, 1976, 178 pp, $9.00. Selective coverage of institutions and individuals involved in all aspects of solar heating of buildings; main emphasis is on U.S., but some foreign groups are included.

SOLAR DIRECTORY...C. Pesko (ed); Ann Arbor Science Publishers, Inc., Ann Arbor MI 48106, 1975, $20.00. An overall guide to solar energy activity, U. S. and foreign; covers information services, manufacturers, distributors, research activities, projects; bibliography.

DIRECTORIES CONT'D

SOLAR ENERGY AND RESEARCH DIRECTORY...Ann Arbor Science Publishers, Inc., Ann Arbor MI 48106, 1977, $22.50. Comprehensive directory of all types of companies involved in various aspects of solar energy technology.

SOLAR ENERGY SOURCE BOOK...C. W. Martz (ed); Solar Energy Institute of America, P.O. Box 9352 Washington DC 20005, 1977, 712 pp, $12.00. Loose-leaf guide to manufacturers and organizations; periodic updates provided to members.

*SOLAR INDUSTRY INDEX...Solar Energy Industries Association, 1001 Connecticut Ave., NW, Ste. 632, Washington DC 20036, 1977, 381 pp, $8.00 + $2.00 Mailing. Comprehensive guide to manufacturers and service organizations; also includes chapter on operations and economics of solar systems.

SOLAR UPDATE...Environment Information Center, 124 E. 39th St., New York NY 10016, 1977, $25.00. Guide to information sources in solar energy.

PERIODICALS

ALTERNATIVE SOURCES OF ENERGY...Alternate Sourcesof Energy, Inc., Route 2, Box 90A, Milaca MN 56353, Quarterly, $10.00/yr. Combination of articles, columns and features on many aspects of energy alternatives; serves as a clearinghouse for exchange of ideas and technologies.

THE MOTHER EARTH NEWS...The Mother Earth News, Inc., 105 Stoney Mountain Road, Hendersonville NC 28739, Bi-monthly, $10.00/yr. Down-to-earth descriptions of peoples' experiences with alternative lifestyles, ecology and energy; source for what is happening in energy at the grass roots level.

*SOLAR AGE...Solar Vision, Inc., Church Hill, Harrisville NH 03450, Monthly, $20.00/yr. Brief articles on developments in solar energy applications, with emphasis on solar heating and cooling.

*SOLAR ENERGY...Pergamon Press, Inc., Maxwell House, Fairview Park, Elmsford NY 10523, Bi-monthly $100.00/yr. (Included with membership in International Solar Energy Society - $20.00). Contains scientific and engineering papers on all aspects of solar energy and technology, theory, and applications.

SOLAR ENERGY DIGEST...CWO-4 W. B. Edmondson, PO Box 17776, San Diego CA 92117, Monthly, $28.50. Concise summaries of solar energy developments, on-going research and publications, both U.S. and foreign.

SOLAR ENERGY INTELLIGENCE REPORT...Business Publishers, Inc., PO Box 1067, Silver Spring MD 20910, Bi-weekly, $90.00. Covers the Washington beat in solar energy; also new developments, markets, meetings.

*SOLAR ENGINEERING...Solar Engineering Publishers, Inc., 8435 N. Stemmons Freeway, Suite 880, Dallas TX 75247, Monthly, $15.00/yr. Short (1-3pages) descriptions of activities and developments in the field of solar energy, particularly in the private sector and in the U.S.

*SOLAR HEATING & COOLING...Gordon Publications, P. O. Box 2126-R, Morristown NJ 07960, Bi-monthly, $6.00/yr. Short articles on solar heating and cooling issues, developments and equipment. Oriented to builders, developers, and manufacturers.

SOLAR UTILIZATIONS NEWS...Alternate Energy Institute, PO Box 3100, Estes Park CO 80517, Monthly, $8.00/yr. Covers regional developments, publications and meetings.

GOVERNMENT PUBLICATIONS

*BUYING SOLAR...Federal Energy Administration; Stock No. 041-018-00120-4, GPO, June 1976, 71 pp, $1.85. Guide to factors a homeowner should consider when buying solar systems.

ERDA'S PACIFIC REGIONAL SOLAR HEATING HANDBOOK...Los Alamos Scientific Laboratory; Stock No. 060-000-0024-7, GPO, Nov. 1976, 108 pp, $3.25. Guide for engineers, architects, and individuals familiar with heating and ventilating applications who wish to design a solar heating system for buildings in the Pacific Coast Region; basic concepts are useful in other regions.

A GUIDE TO FEDERAL PROGRAMS OF POSSIBLE ASSISTANCE TO THE SOLAR ENERGY COMMUNITY...Congressional Research Service; Stock No. 052-070-04080-7, GPO, 1977, $4.00. Report on existing programs which provide help to individuals and organizations interested in using solar energy.

HOME MORTGAGE LENDING AND SOLAR ENERGY...D. Barrett et al; Stock No. 023-000-00387-2, GPO, 1977, 31 pp, $1.40. Results of a series of interviews with mortgage loan officers at financial institutions in New England, main focus was on mortgage financing for new housing with solar energy space heating systems.

*HUD INTERMEDIATE MINIMUM PROPERTY STANDARDS SUPPLEMENT: SOLAR HEATING AND DOMESTIC HOT WATER SYSTEMS...Order No. 4930-2, GPO, 1977, $12.00 (including updates). Contains solar requirements and standards applicable to one and two family dwellings, multifamily housing, and nursing homes and intermediate care facilities.

NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING OF BUILDINGS...Energy Research and Development Administration; Stock No. 060-000-00043-3, GPO, 1976, 84 pp, $1.55. Reflects results of continuing assessment of the Program during 1976.

*NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING OF BUILDINGS: PROJECT DATA SUMMARIES, Vol. 1-COMMERCIAL AND RESIDENTIAL DEMONSTRATIONS, Stock No. 060-000-00012-3, 1976, 163 pp, $2.35; Vol. 2-DEMONSTRATION SUPPORT, Stock No. 060-000-00042-5, 1976, 61 pp, $1.25; Vol. 3-RESEARCH AND DEVELOPMENT, Stock No. 060-000-00018-2, 1976, 99 pp, $1.90...Systems Consultants, Inc., GPO, 1976. Brief abstracts of projects funded by ERDA and conducted under the National Program for Solar Heating and Cooling of Buildings through July 1976. Vol. 2 reports on development projects in the areas of collectors, thermal energy storage, solar heat pumps, solar cooling systems and controls.

*SOLAR DWELLING DESIGN CONCEPTS...AIA Research Corporation: Stock No. 023-000-00334-1, GPO, May 1976, 136 pp, $2.30. Discusses all facets of the design and siting of housing intended to be heated by the sun; also includes discussion of the impact of solar energy utilization on traditional dwelling design.

SOLAR ENERGY IN AMERICA'S FUTURE: A PRELIMINARY ASSESSMENT...Energy Research and Development Administration; Stock No. 060-000-00051-4, GPO, March 1977, 104 pp, $2.00. Documents a Stanford Research Institute study of the potential roles that solar energy technologies could have for meeting U.S. energy needs over the next 45 years.

SOLAR HEATING AND COOLING DEMONSTRATION: A DESCRIPTIVE SUMMARY OF HUD SOLAR RESIDENTIAL DEMONSTRATIONS CYCLE 2, Fall 1976...AIA Research Corporation; Stock No. 023-000-00389-9, GPO, 1977, 103 pp, $2.30. Describes solar grant projects selected from the second cycle grant applications in the HUD solar heating and cooling demonstration program; includes drawings of buildings and solar systems.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM: A DESCRIPTIVE SUMMARY OF HUD CYCLE 3 SOLAR RESIDENTIAL PROJECTS, SUMMER 1977...AIA Research Corporation Stock No. 023-000-00418-6, GPO, 1977, 165 pp, $3.50. Describes the projects selected from the grant applications for the third cycle in the HUD solar heating and cooling demonstration program; sketches of buildings included.

SOLAR PROGRAM ASSESSMENT: ENVIRONMENTAL FACTORS - SOLAR HEATING AND COOLING OF BUILDINGS... Energy Research and Development Administration; Stock No. 060-000-00060-3, GPO, March 1977, 76 pp, $2.20. Presents the environmental issues associated with the further development of solar heating and cooling.

The publications on this page are available from GPO. They can be obtained by writing: Superintendent of Documents, Government Printing Office, Washington DC 20402. The other materials are NOT available through the National Solar Heating and Cooling Information Center. They can be obtained by contacting the publishers, bookstores, or local libraries.

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